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## FOREIGN TECHNOLOGY DIVISION



— ANOMALIES OF THE IONOSPHERIC  $F_2$ -LAYER ABOVE GUANGZHOU REGION

by

Huang Qingming



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## ANOMALIES OF THE IONOSPHERIC F<sub>2</sub>-LAYER ABOVE GUANGZHOU REGION

Huang Qingming

China Research Institute of Radiowave Propagation

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### Abstract

→ The Guangzhou Ionospheric Observatory is located near the geomagnetic equator (geomagnetic coordinates: 183.0°E, 11.5°N). According to the analysis of ionospheric data from 18 observatories, Guangzhou is situated at the north crest of the double-crest where foF<sub>2</sub> reaches its maximum value. During high solar activity years, the maximum value of foF<sub>2</sub> occurs even at night time. In addition, the occurring frequency of the ionospheric disturbances is higher than that at other observatories in our country. These characteristics are all considered equatorial anomaly phenomena of the F<sub>2</sub>-layer.

### I. F<sub>2</sub>-Layer Crest

The equatorial anomaly of maximum electron density in the ionospheric F<sub>2</sub>-layer--the double-crest phenomenon, has long been written about by many scientific workers. This paper uses data from 18 ionospheric observatories located throughout the Asian

Pacific region, as shown in Table 1, and takes data of the month mean value at 1200LT for  $f_oF_2$  of March 1969 during the peak solar activity year to conduct the analysis. As shown in Fig. 1, the high-noon value of maximum electron density of  $F_2$ -layer is a function of geomagnetic latitude, but its peak value with respect to latitude distribution does not occur at the point directly beneath the sun where the photochemical rate of ionization is maximum; rather, it occurs on both sides of the north and south magnetic latitude of the geomagnetic equator. Based on the results obtained from the analysis of ionospheric observatory data, the location of one of its double-crest is at  $11.5^\circ\text{N}$  north magnetic latitude (i.e., Guangzhou Observatory) and the other one is at about  $18.6^\circ\text{S}$  south magnetic latitude (i.e., Port Moresby Papua, New Guinea). This peak value of the latter, however, is not precisely at the location of this observatory because there lacks ionospheric observatory information between south magnetic latitude  $10$ – $17^\circ$ . But the north latitude location of the peak value for the former is considered more reliable because during the analysis the corresponding  $f_oF_2$  month mean values and 5-day mean values at Guangzhou Observatory had been compared with data (based on the  $f_oF_2$  5-day mean value data obtained during the observation period of the total solar eclipses in April 1970 at Hongkong, October 1976 at Kunming and February 1980 at Ruili) from Hongkong Ionospheric Observatory (geomagnetic latitude  $10.8^\circ\text{N}$ ), Kunming Temporary Ionospheric Observatory (geomagnetic latitude  $13.6^\circ\text{N}$ ) and Ruili Temporary Ionospheric Observatory (geomagnetic latitude  $12.5^\circ\text{N}$ ) that are near the observatory at the said latitude, and as shown in Table 2 the  $f_oF_2$  values at Guangzhou Observatory are greater than those values at other observatories. Although the location of peak value will shift and can not be accurately determined, by and large it is near the space over this latitude.

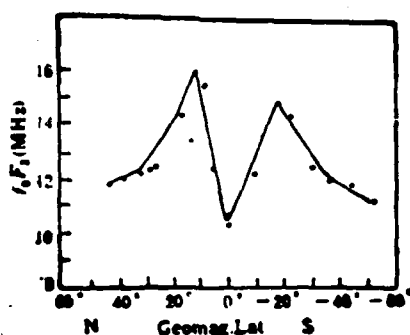


Fig. 1 Double-crest distribution of  $f_oF_2$

Table 1. Location of ionospheric observatories

(1) 站名	(2) 地理纬度	(3) 地理经度	(4) 地磁纬度	(5) 地磁经度
Khatuk	52.5°N	134°E	41.4°N	175.0°E
Manzhouli	49.6°N	117.4°E	39.0°N	184.5°E
Changchun	43.9°N	125.4°E	32.2°N	192.5°E
Beijing	39.9°N	116.1°E	28.2°N	185.7°E
Lanzhou	36.0°N	103.9°E	25.2°N	174.9°E
Chongqing	29.4°N	106.5°E	17.4°N	176.5°E
Guangzhou	23.1°N	113.2°E	11.5°N	183.0°E
Haikou	20.0°N	110.3°E	8.5°N	180.1°E
Manila	14.6°N	121.1°E	6.0°N	182.0°E
Tiruchirapalli	10.8°N	78.7°E	1.0°N	148.7°E
Thimba	8.6°N	76.9°E	1.0°N	145.0°E
Singapore	1.3°N	103.8°E	9.6°S	173.0°E
Port Moresby	9.4°S	147.1°E	18.6°S	217.9°E
Cocos Is.	12.2°S	96.8°E	22.0°S	165.0°E
Townsville	19.3°S	146.7°E	29.0°S	217.0°E
Brisbane	27.5°S	152.9°E	37.0°S	226.0°E
Canberra	35.5°S	149.0°E	44.0°S	225.0°E
Hobart	42.8°S	147.5°E	52.0°S	223.0°E

Key: (1) Observatory name; (2) Geographic latitude; (3) Geographic longitude; (4) Geomagnetic latitude; (5) Geomagnetic longitude

Table 2 Comparison table for  $f_oF_2$  at Guangzhou Observatory and Hongkong, Kunming, Ruili Observatories

(1) 站名 \ (2) 时间	00	01	02	03	04	05	06	07	08	09	10	11
Guangzhou	15.4	15.5	13.1	9.4	6.7	6.3	6.5	8.9	10.9	11.7	12.6	14.2
Hong Kong	15.7	15.5	14.2	9.0	6.5	5.8	6.3	8.8	10.9	11.5	12.5	13.8
Guangzhou	4.6	4.2	3.9	4.2	2.7	2.2	2.6	5.7	7.0	7.6	9.3	10.7
Kunming	3.7	3.6	3.3	3.3	2.7	1.6	3.1	6.3	6.9	7.5	9.0	10.0
Guangzhou	14.0	12.7	12.1	12.3	10.2	6.5	4.2	6.3	10.7	12.0	12.9	13.5
Ruili	F	13.0	12.0	F	F	6.5	3.6	3.5	6.0	9.5	12.0	12.8

(1) 站名 \ (2) 时间	12	13	14	15	16	17	18	19	20	21	22	23
Guangzhou	16.3	17.0	16.9	17.2	17.2	17.2	17.0	16.4	16.1	16.0	16.5	15.9
Hong Kong	15.0	15.0	16.5	16.5	16.5	16.7	16.5	15.8	16.0	16.0	15.6	16.0
Guangzhou	12.2	13.5	14.5	14.4	13.9	12.8	10.4	8.0	6.6	6.2	5.6	4.8
Kunming	10.6	12.8	13.4	13.0	11.8	9.4	7.8	6.0	5.0	4.7	3.7	3.7
Guangzhou	14.4	15.2	15.7	15.6	15.5	15.6	15.0	15.0	14.2	14.7	14.5	14.2
Ruili	14.0	14.2	15.2	15.5	16.2	16.2	14.5	15.1	14.2	8	8	F

Key: (1) Observatory Name; (2) Time

People believe that the mechanism of the formation of equatorial anomalies for  $F_2$ -layer parameters is the "spring effect". That is, there is a "motor" region<sup>[4]</sup> originated from the electric field generated by the atmospheric generator and transmitted to the  $F_2$ -layer along the magnetic lines of force at about 110 km in the E-layer near the equator. In the day time they make the plasma there move upward and the lifted plasma disperses downward along the magnetic lines of force, thus causing them not to return to the original place and making them reach the two places north and south of it. Therefore, the electron density above the geomagnetic equator decreases, whereas it increases in the two regions on both sides of it.

## II. Weekly Diurnal Variations of Equatorial Anomalies $f_oF_2$

The Guangzhou Observatory is located near the north peak point of the double-crest phenomenon and its weekly diurnal variations are more complex. Here the month mean value data of  $f_oF_2$  for the said observatory are made into figures of weekly diurnal variation curves based upon the representative months (January, April, July, October) of seasons during the period of high solar activity years (1979, 1980, 1981) and minimal solar activity year (1976). As shown in Fig. 2, Fig. 2a is the  $f_oF_2$  weekly diurnal variation curves for the representative month of spring. During the period of high sunspot activity years,  $f_oF_2$  increases more slowly after sunrise while reaching its maximum value at 1300LT and its maximum value almost remains constant continuing into mid-night at 0200LT. Fig. 2b is the  $f_oF_2$  weekly diurnal variation curves for the representative month of summer. During high solar activity years,  $f_oF_2$  always rises very slowly while reaching its maximum value at 1600LT and then starts to decrease slowly after staying constant for about 3 hours. Fig. 2c is the  $f_oF_2$  weekly diurnal variation curves for the representative month of autumn. During high solar activity years,  $f_oF_2$  increases rapidly after sunrise while reaching the maximum value at 1400LT and its maximum value still occurs even until mid-night at 0000LT. Fig. 2d is the weekly diurnal variation curves for the representative month of winter. During high solar activity years,  $f_oF_2$  rises sharply after sunrise and reaches the maximum value very quickly, then it starts to drop after maintaining its maximum value until 2200LT. Yet, during minimal solar activity years no maximum value of  $f_oF_2$  occurs at all at night time during any of the seasons.

During high solar activity years,  $f_oF_2$  of the season-separating month continues to maintain its maximum value all the way to around mid-night after reaching the

maximum value at about 1300LT, while the maximum value of  $f_oF_2$  in the winter can also be maintained until 2100LT. Judging from this, the maximum value of  $F_2$ -layer will continue to occur at night time with the season-separating month of a high solar activity year being the most obvious and summer and winter months coming in second; however, none of the seasons in minimal solar activity years have this phenomenon happened at night time. Why does the maximum value of the critical frequency of  $F_2$ -layer still occur at night time after sunset and sometimes its peak value is even greater than that at day time? The common explanation is that this is caused by structural changes in the geomagnetic field<sup>[1]</sup>,  $E \times B$  shift<sup>[2]</sup> and effects of neutral wind as well as plasma flow from the magnetic layer, etc.

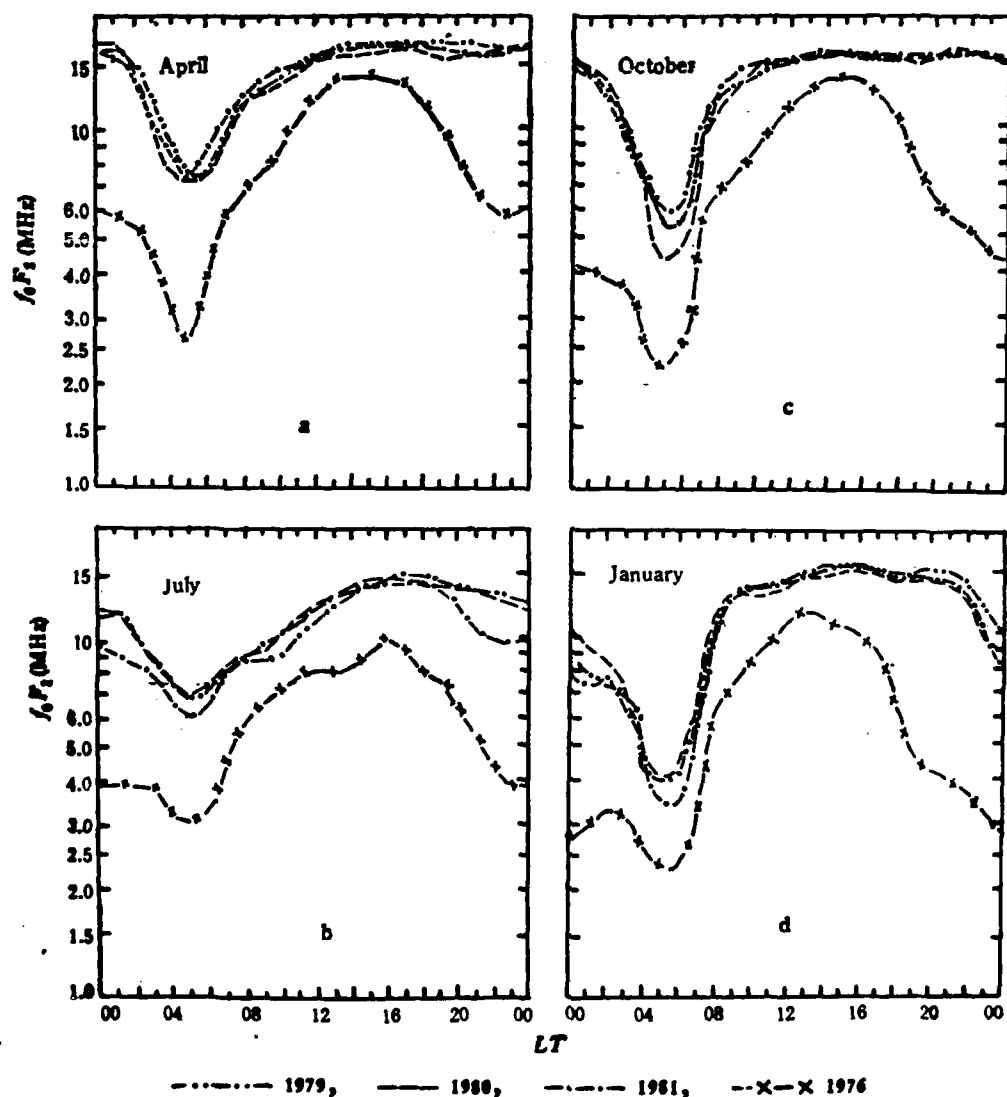


Fig. 2 Seasonal behavior of diurnal variations of  $f_oF_2$  in different solar activity years



The conjectures on the effects of neutral wind in the F region have been around for at least 60 years. Johnson<sup>23</sup> pointed out that the atmospheric pressure around the globe at about 200 km is almost constant; but it is not so above this altitude. In fact, based on analysis of probes in the movements of satellites, large scale variations for both day and night time in atmospheric density are indeed being calculated. This kind of observations indicate that there is very large horizontal pressure gradient which forms the gigantic motive force for wind. Geisler along with Hohl and King adopted Jacchia's temperature distribution model and conducted detailed computations on wind systems that included wind systems blowing at a speed of 100 m/sec from the heated side of the earth along the equator and cutting across the two poles toward the cooler night side to make ionized gas move upward along the slanting magnetic lines of force to places where the electron depletion rate is smaller. This method provides the wind blowing toward the equator at night time to explain the continuous occurrence of F<sub>2</sub>-layer at night time.

### III. Ionospheric Disturbances Phenomena

Ionospheric disturbances are primarily due to the large quantity of electricity-charged particle flows or plasma "clouds" being thrown out when there are local disturbances in the sun. These particle flows penetrate the boundary of magnetic layer and interact with high altitude atmosphere to destroy the normal F<sub>2</sub>-layer conditions thereby generating ionospheric disturbances. The ionospheric disturbances are classified into three types: one type is called the negative ionospheric disturbances (foF<sub>2</sub> drops), another type is called the positive ionospheric disturbances (foF<sub>2</sub> increases) and the third type is the dual ionospheric disturbances (foF<sub>2</sub> both increases and drops). Those near the equatorial region are generally considered to be mainly positive disturbances. Based on the information from the 5 ionospheric observatories of Manzhouli, Beijing, Chongqing, Guangzhou and Haikou, etc., the deviation value  $\Delta f_o F_2$  of foF<sub>2</sub> that deviates from the normal value each hour is computed from the monthly report on ionospheric behaviors, and when the computed  $\Delta f_o F_2$  continues to be  $\geq \pm 15\%$  for over 6 hours, then it is designated as a certain occurrence of ionospheric disturbances. The obtained occurring frequency is shown in Fig. 3 based upon latitude distribution. It can be observed from the figure that 509 times negative ionospheric disturbances and 315 times negative disturbances occurred over Guangzhou, and the occurring frequency of these two types of disturbances is greater than those at other observatories. Generally speaking, negative ionospheric disturbances should occur at

observatories located at higher latitudes. For instance, Manzhouli Observatory should have more occurrences and Haikou Observatory, which is closer to the equatorial latitudes, should have more occurrences of positive ionospheric disturbances. But it is not so in actuality as Guangzhou Observatory has the most occurrences of both positive and negative ionospheric disturbances. The majority of these two types of disturbances occurs at night time. When no disturbances occur at any ionospheric observatories in our country, disturbances often occur at Guangzhou Observatory; when there are no disturbances phenomena in the sun, disturbances sometimes still occur at that observatory. The anomaly phenomenon occurred in the F<sub>2</sub>-layer over Guangzhou may be related to the fact that it is situated at the north peak point of the double-crest and certain dynamic processes.

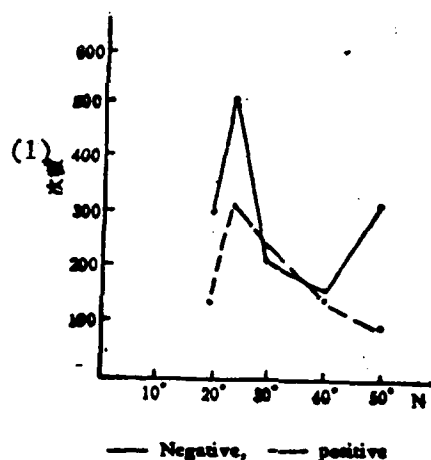


Fig. 3 Latitudinal distribution of the occurrence frequency for the positive and negative ionospheric disturbances during 1965 - 1982.

Key: (1) Number of times

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